USB Memory Stick

An ideal memory device

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In no time at all, the USB Flash Drive or Memory Stick has become one of the most popular memory devices: small, robust, large capacity, no battery. Now that Elektor Electronics are offering a 128-MB USB Memory Stick as a welcome gift to new subscribers, it's high time your favourite electronics magazine told you how it works.

Really useful, such a USB Flash drive. It will fit in your trouser pocket, does not eat batteries and holds lots and lots of computer data. Around for a number of years already, this memory device has become incredibly popular.

So what's inside a Flash Drive and how does it work? Using our welcome gift to new (18-month) subscribers we'll tell you, with a note that the description is applicable to other brands and types, too. The photograph shows that there's preciously little inside a Flash drive. The main components are the Flash memory (the big back slice at the top side) and the controller (with this type, at the underside). There also a couple of smaller SMD parts, a quartz crystal and an indicator LED signalling data access. A small slide switch is fitted at the side to provide write protection.

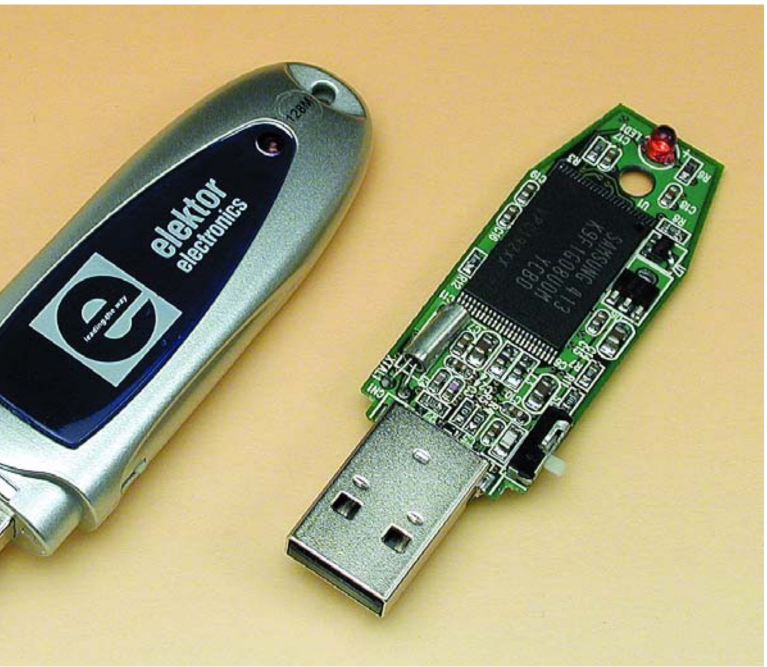
Two ICs

The block schematic structure of the two large ICs is shown in **Figure 1**. The Flash disk controller (here, an OTi-2168) is specially designed for this sort of application. It contains a fast RISC core that handles the complete communication with the Flash memory, enabling the computer connected to the Flash drive to 'think' that a ordinary hard disk is connected to one of its USB ports. Furthermore, the OTi chip contains an integrated fast UB2.0 interface allowing the highest possible data speed of 480 Mbit/s to be achieved.

You may wonder why so much computing power is necessary. The answer is we're not just looking at serial/parallel conversion but also at all the protocols that apply to accessing the Flash memory. Complying with a protocol and thus establishing communication with the Flash memory device over a number of I/O pins is radically different from driving a set of address and data pins on conventional RAM or EEPROM. The Flash memory is a 1024 Mbit (128 Mbyte) 'NAND' type from Samsung driven via eight I/O lines. The controller issues commands for reading, writing or erasing while also supplying the relevant addresses and data.

Changing the drive letter

Normally, Windows XP will automatically assign the next available drive letter in the system when a memory stick is plugged into a USB port for the first time. However, problems may arise In a network environment where access is granted to drives on a another computer (like a server). In such cases, it may happen that the memory stick is assigned the same letter as one of the network drives, or is not 'visible' at all. Such problems may be prevented by assigning a different drive letter to your memory stick. In the Start menu, go to **Settings/Control Panel/Administrative Tools**, and open **Computer Management**. In the left-hand area of the window, click on **Storage – Disk management**, this will make all available drives show up in the right-hand area. Find the USB memory stick and right-click on its symbol. Select **Change Drive Letter and Paths**, and assign a free letter to the drive, for example, Z.'



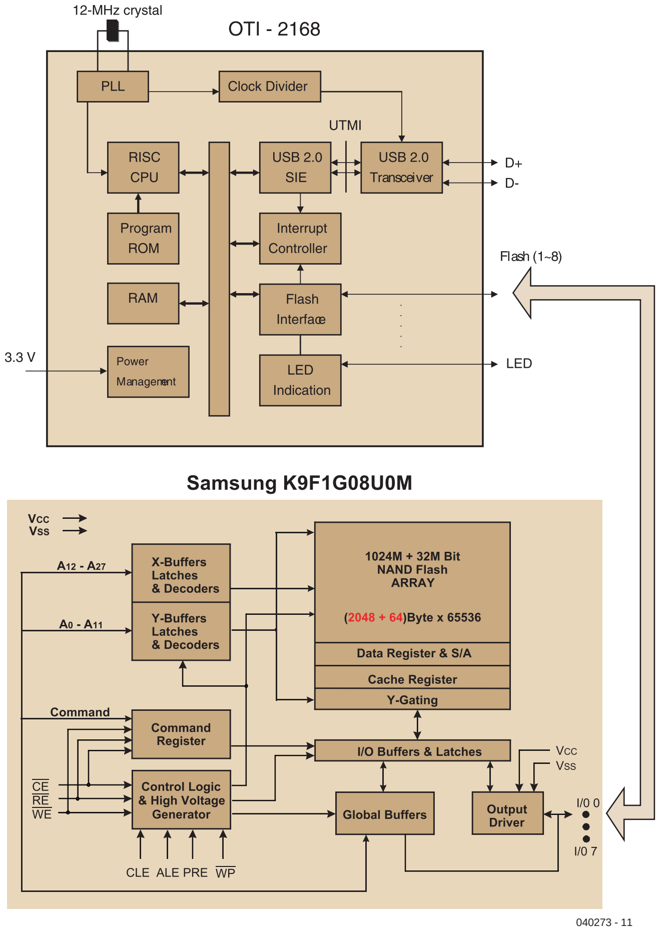


Figure 1. Two complex ICs rule in a USB Flash drive: a dedicated microcontroller and a NAND Flash memory.

The block diagram gives a fair impression of the memory chip complexity — a lot of intelligence lurks inside the memory to make sure all processes run properly.

One of the main points to note with any Flash memory is reliability. Flash memory cells do not have eternal life an the odd cell may malfunction during operation. That's why an extensive internal error checking system is available (ECC, error correction code). With all operations, (read, write, but also erasure), the data integrity is checked. In case an error is found, it is corrected and the contents of the entire 'block' containing the error is copied to another, free, block in the memory.

The manufacturer claims a lifetime of 100,000 erasure and write cycles to the device. Data is held in the memory cells for at least 10 years.

How does a Flash memory work?

The basic construction of Flash memory is derived from the EPROM. Each memory cell consists of MOSFET with two gates (**Figure 2**). A floating gate is 'inserted' between the control gate and the substrate of the FET. This floating gate employs an extremely thin layer of silicon dioxide hence forms a nearly perfect isolation, preventing electronics injected into the gate from leaking away when the supply voltage is switched off. The number of electrons present on the floating gate determines if a logic High or Low level is being stored. Cell programming and erasure is effected by applying a relatively strong field between gate and substrate, allowing electrons to travel across the isolation barrier. This process is called Fowler-Nordheim tunnelling.

In the mean time, millions of USB memory sticks and cards have proved the reliability of Flash-based memory devices — they can be relied upon to keep your data secure for many years.

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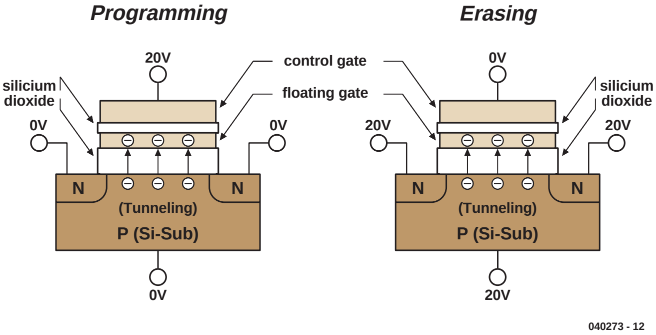

Figure 2. Basic operation of a Flash memory cell (source: Toshiba).